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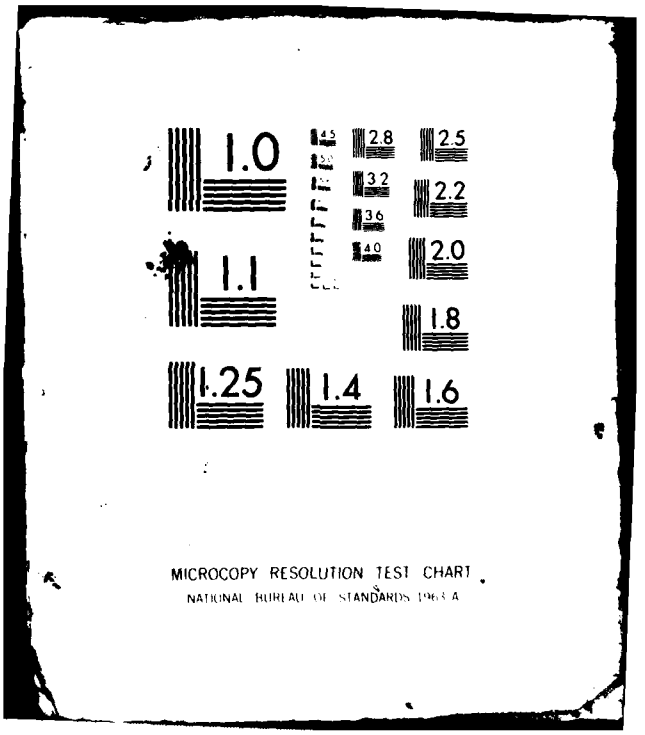
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TECHNICAL REPORT RT-81-7

ELECTROMAGNETIC INTERFERENCE (EMI) EVALUATION OF FOUR DIGITAL SCALES

Robert A. Snead
Test and Evaluation Directorate
US Army Missile Laboratory

1982

A

1 November 1981

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898

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Radio Interference
Explosive Safety
Ordnance Safety

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

As a result of safety considerations, the Electromagnetic Interference emissions of four digital scales were measured. The results were reviewed to determine the possibility of accidental detonation of live ordnance being weighed on the scales.

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A

I. BACKGROUND

In April 1981, the Electromagnetic and Nuclear (EM&N) Effects Group (DRSMI-RTS) of the Test and Evaluation (T&E) Directorate, US Army Missile Laboratory, US Army Missile Command, was requested to investigate the Electromagnetic Interference (EMI) caused by four sets of digital scales used by T&E Directorate's Environmental Test Group, located in Building 7290. The EMI was of concern because the scales were being used to weigh electro explosive devices, and live ordnance.

After the scales were delivered to the Environmental Test Group, and warning stickers were noted, EM&N Effects Group was contacted by the purchaser and asked to evaluate the scales from an EMI standpoint. All four of the scales purchased were provided as follows:

- Pennsylvania Scales Model EWO 4020, Serial #133467
- Pennsylvania Scales Model 4100 T, Serial #135462
- Pennsylvania Scales Model EWO 4020, Serial #133474
- NCI Model 3020, Serial #3230810575

The evaluation of the scales was directed toward two objectives:

- Determine why the warning stickers were on the scales
- Calculate the total power contained in the scales' broadband emission waveform

The first objective was accomplished by placing a phone call to the Pennsylvania Scales plant. Mr. Curt Killheffer, an engineer in their design group, indicated that no EMI control consideration was given in the product design. He also indicated that the reason for the warning sticker was to caution users against using the scales in an explosive or combustible atmosphere.

II. TEST PROCEDURES

The evaluation of the hazard required the development of the following analysis procedure to calculate the power contained in a broadband waveform, since the digital scale emissions were primarily broadband emissions. This procedure is the subject of a forthcoming MICOM technical report.

The total power contained in the EMI waveform was calculated by the following procedure:

- The EMI waveform was recorded using an HP8568A Spectrum Analyzer.
- An approximation using linear equations of the form $y = mx + b$ was used to model the recorded response and generate an approximation of the original curve.

- An approximation of the receiving antenna's antenna factors of the for $y = m \log x + b$ was used to correct the measured signal at each frequency for the receiving antenna gain and convert to an electric field spectral density.

$$V(dBuV) + AF(dBuV/m) = E(dBuv/m) \quad (1)$$

- The logarithmic field spectral density was then converted to a linear field spectral density by a point-by-point application of

$$E(V/M) = 10^{\frac{E(dBuV)}{20}} - 6 \quad (2)$$

- The power spectral density was calculated by a point-by-point application of

$$P_D = E^2/377 \quad (3)$$

- The power coupled into the Electroexplosive Devices (EED) by each frequency component was then calculated, assuming no coupling loss and that the EED leads formed a resonant dipole by

$$P = \frac{P_D(1.65)L^2}{4\pi} \quad (4)$$

- The total power coupled into the EED was then calculated by summing the power of each of the spectral components.

III. TEST RESULTS

For the worst of the four scales, this method calculates a worst-case power of approximately 2×10^{-7} watts induced at 1 meter from the source.

IV. CONCLUSIONS AND RECOMMENDATIONS

- On the basis of the data obtained for the four scales tested, it appears that an acceptable safety margin exists between the power contained in the scale EMI, approximately 2×10^{-7} watts, and the no-fire power of the squibs (approximately 1×10^{-3} watt minimum). This would make the chance of accidental ignition due to EMI from the scales extremely remote.

- Some of the scale systems carry a conspicuously mounted warning label: CAUTION: DO NOT USE IN HAZARDOUS LOCATIONS. The manufacturer does no EMI tests, and intends these signs primarily to warn customers against using these scales in explosive atmospheres. Since the switches and buttons are not sealed, unimpeded airflow is allowed between the inside and outside of the instrument, and no explosion or flame suppression devices are provided; however, it should be noted that if an accidental detonation of an EED, warhead, or motor

occurs in the vicinity of one of these scales, the warning stickers would immediately cast suspicion on the scales, whether or not they are actually responsible for the accident.

- Individual digital systems/equipment, even from the same manufacturer, produce differing amounts of EMI due to differences in board layout, components, and construction techniques. Therefore, every scale used in an area where EED's or motors are used should be tested for EMI emissions.

- As the equipment ages, shields deteriorate, chips age, and components change value. Thus, every scale used in a location near EED's or motors should be retested periodically.

- The cases of the scales are plastic and thus can accumulate static charges. The cases should be painted or coated with an antistatic treatment or conductive paint and electrically bonded to the aluminum scale base casting.

- Discussions with Pennsylvania Scales indicate the manufacturer does produce a scales system with a remote weighing platform and load cell. Such a system would significantly reduce the EMI at the object being weighed since the readout and processor would be at least 1 meter away.

APPENDIX A

TYPICAL SQUIB CHARACTERISTICS

TYPICAL SQUIB CHARACTERISTICS

Device	Output	Size (in.) Length	Size (in.) O.D.	Ignition (see Section 4.6) Resistance (ohms)	MNFC (amp.)	RFC (amp.)
Open-match type, end flash						
M1A1 *	brisk flame burst	0.37	0.27	0.75-1.25	0.25	2.0
S6E0	brisk flame burst	3/8	0.233	1.3-2.0	0.3	1.0
S6H0 *	coruscating, hot slag	3/8	0.233	1.3-2.0	0.3	1.0
S42E0 *	jet flame	1/4	0.193	4-8	0.05	1.0
S55A0 *	brisk flame burst	0.43	0.254	1-2	0.25	2.0
Thin-bottom type, end flash						
MK1 Mod 0*	sharp flame burst	0.45	0.271	0.7-1.3	0.2	1.5
MK2 Mod 0*	sharp flame burst	0.43	0.283	0.14-0.2	1.0	5.0
XM3 *	sharp, coruscating burst	0.35	0.287	0.7-1.0	0.45	5.0
S11A2 *	jet flame	1.36	0.299	1.4-2.6	0.25	2.0
S11F0 *	jet flame	1.36	0.299	1.4-2.6	0.25	2.0
S118A1 *	hot slag and jet flame	0.76	0.308	0.05-0.09	1.0	5.0
Side-burning type						
S26B0 *	coruscating match	1/4	0.15	0.1-0.3	1.5	3.0
S107A0	brisk flame burst	3/4	0.283	0.04-0.08	2.0	5.0
S124A0	sharp burst and hot slag	0.45	0.285	1.0-2.5	0.25	2.0
S135A0	coruscating slag	5/8	0.235	0.1-0.3	1.5	3.0
S31F6	hot gas	0.4	0.179	3-7	0.1	1.0
Screw-in type						
S18A2	coruscating	0.61	3/8x24 threaded	3-9	0.05	1.0
S177A2	thin bottom	1.09	1/2x20 threaded	0.05-0.13(1)	1.0	4.5
One amp.-one watt no-fire type						
S179A0	screw-in, thin bottom	1.09	1/2x20 threaded	1.0-1.8(1)	1 a./1 w.	5.0
S193A0	thin bottom	0.42	0.283	0.75-1.0	1 a./1 w.	4.5
S205A0	thin bottom	1.36	0.299	0.75-1.0	1 a./1 w.	4.5

* Stock items (see Section 14.2.2)
(1) Two circuits

APPENDIX B

MEASURED DATA

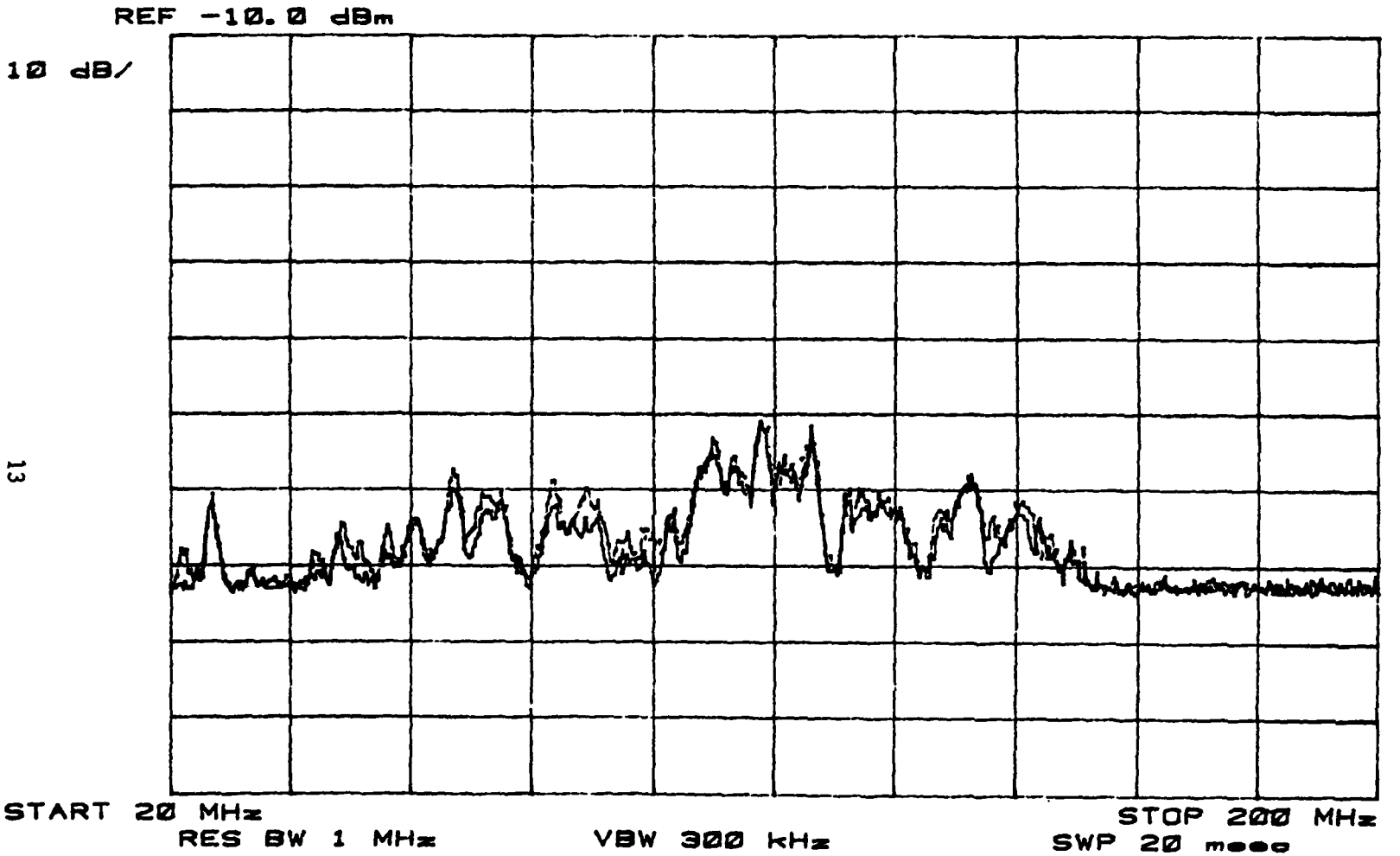

Figure B-1. Pennsylvania Scales, Model EWO 4020, Serial #133467.

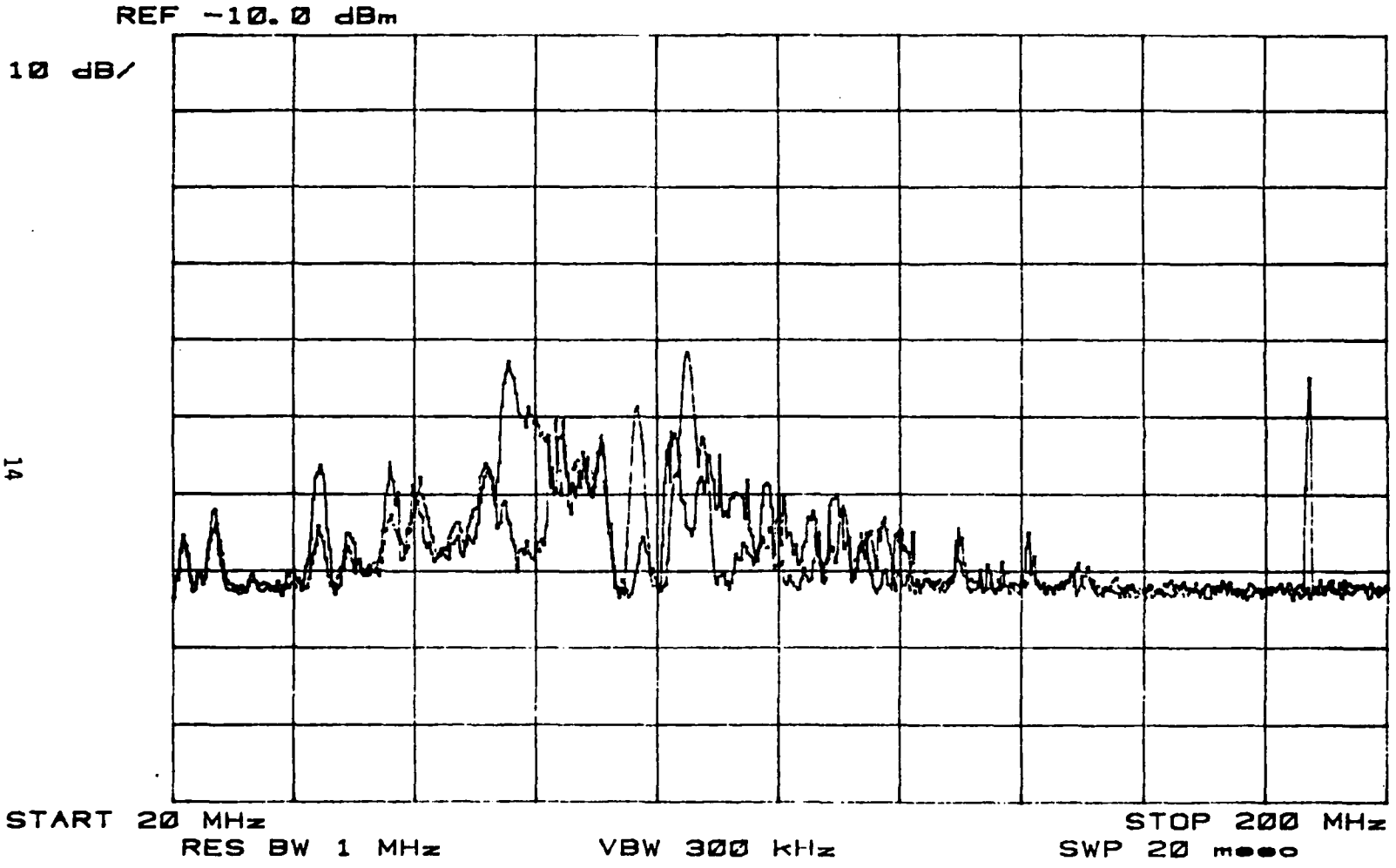

Figure B-2. Pennsylvania Scales, Model 4100 T, Serial #135462.

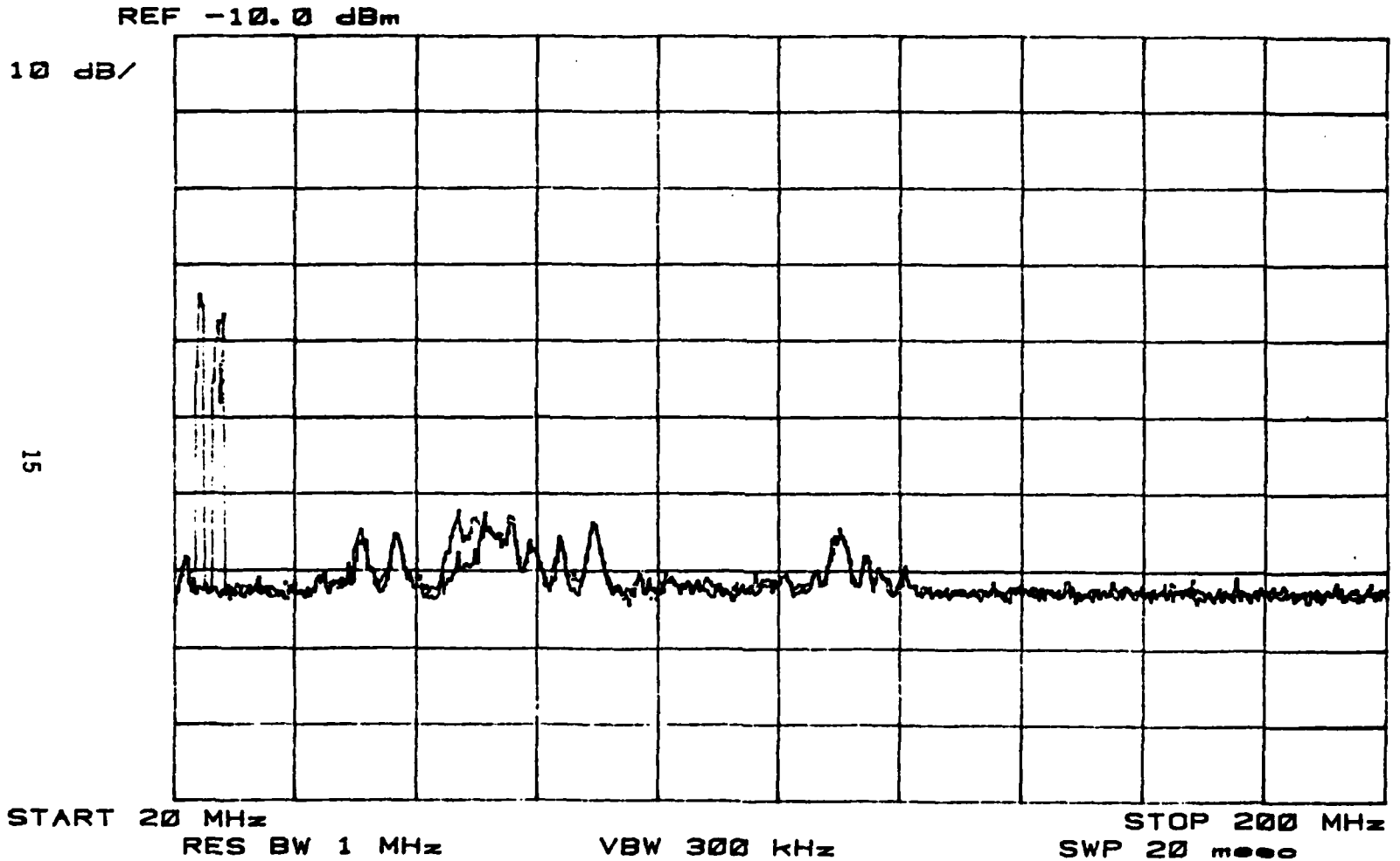

Figure B-3. NCI Model 3020, Serial #3230810575.

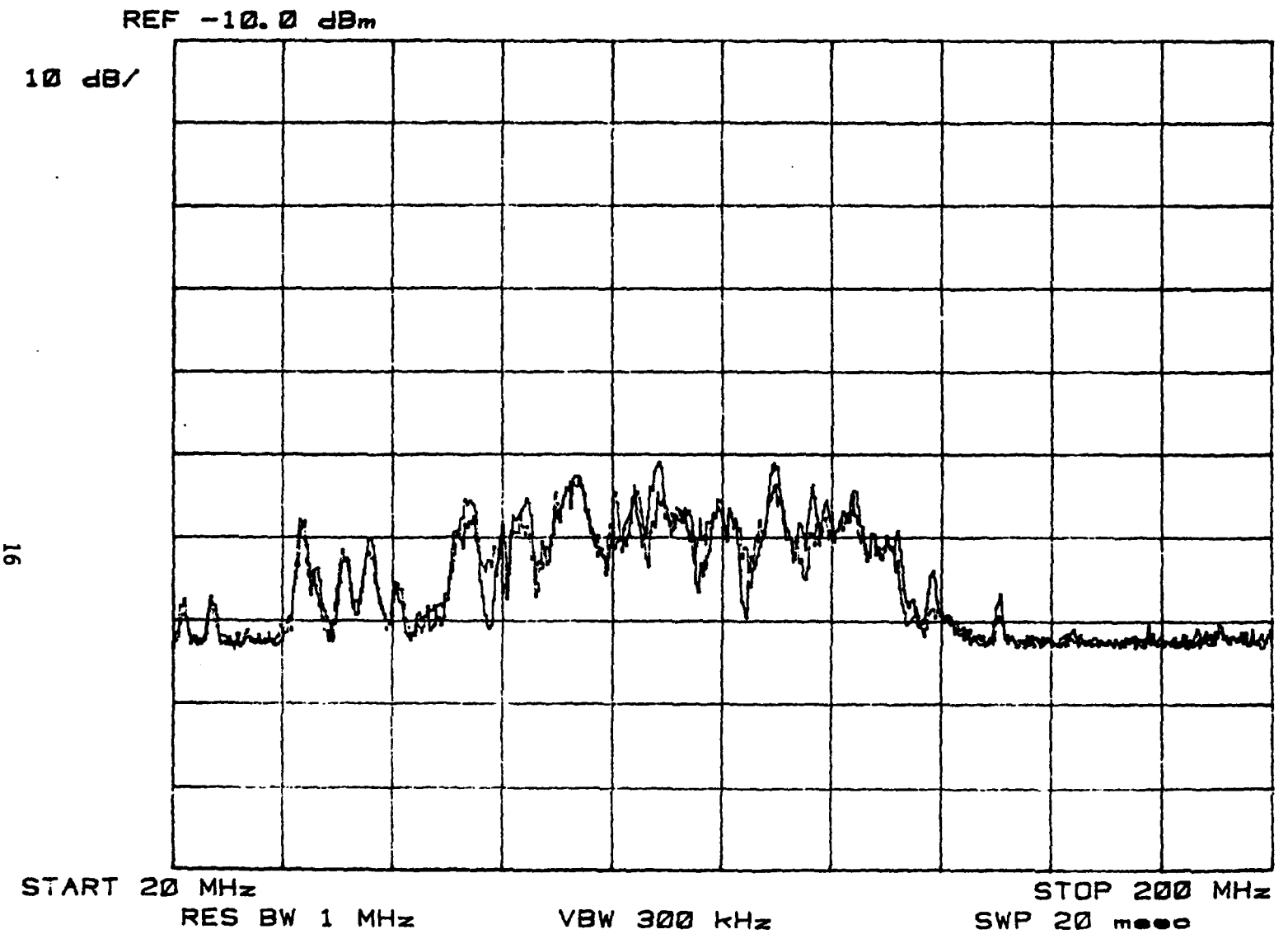

Figure B-4. Pennsylvania Scales, Model EWO 4020, Serial #133474.

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